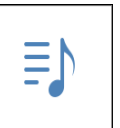




Armed Forces College of Medicine AFCM





Skeletal Muscle Fibers (2)

Prof. Dr. Hanan A. Saleh
Dr. Samaa Kamar



Intended Learning Objectives (ILO)



By the end of this lecture the student should
be able to:

- **Describe** the microscopic structure and correlated function of the skeletal muscle fibers.
- **Describe** the microscopic structure of skeletal muscle receptors and effectors.
- **Interpret** the defective microscopic structure of the skeletal muscle in different diseases.



Key Points



- ❑ **Structure of Skeletal muscle:**
 - **E.M. of skeletal muscle fibers:**
 - **Sarcolemma & transverse tubules**
 - **Sarcoplasmic Reticulum & Traid Tubular System**
 - **Mitochondria & Ribosomes**
 - **Inclusions: Myoglobin & glycogen**
- ❑ **Types of skeletal muscle fibers.**
- ❑ **Growth and regeneration of skeletal muscle & clinical applications.**
- ❑ **Innervations of Skeletal muscle & clinical applications.**

Skeletal Muscle Fiber (T.E.M.)

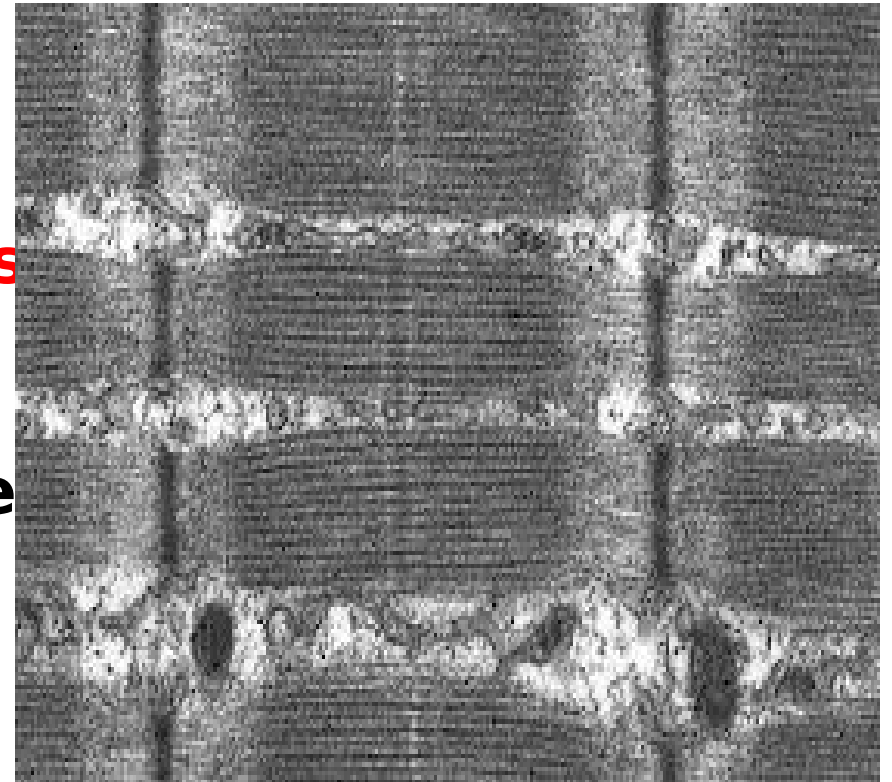


Organelles:

1. Myofibrils & myofilaments
2. Sarcolemma & transverse tubules
3. Sarcoplasmic Reticulum
4. Mitochondria & Golgi & Ribosome

Inclusions:

- Myoglobin & glycogen



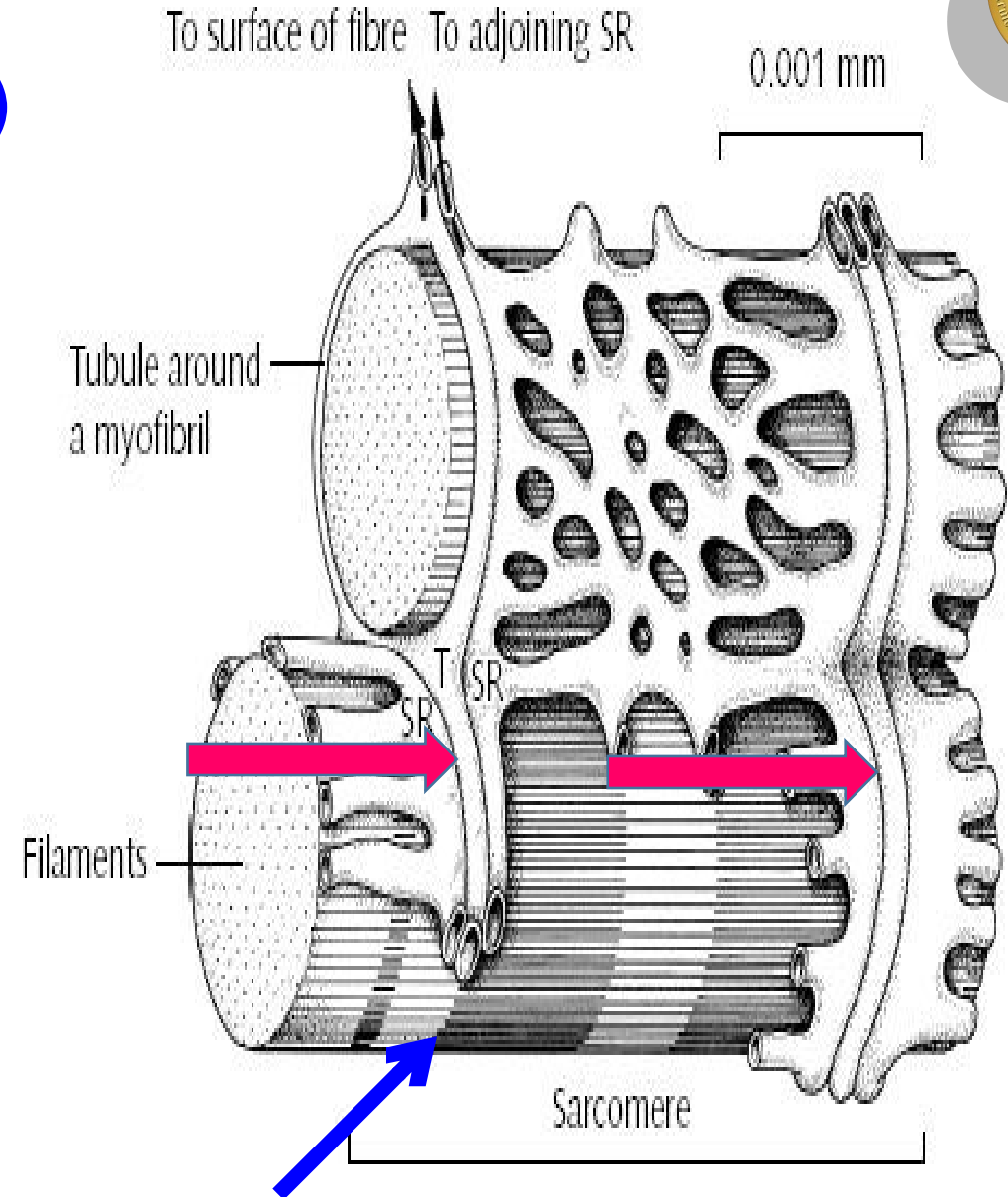
<http://www.bu.edu/histology/i/2160300a.jpg>

2) The Sarcolemma & The transverse tubule (T-tubule)

-The **sarcolemma** sends transverse invagination into **sarcoplasm** →

T-tubules at **A-I** bands junction

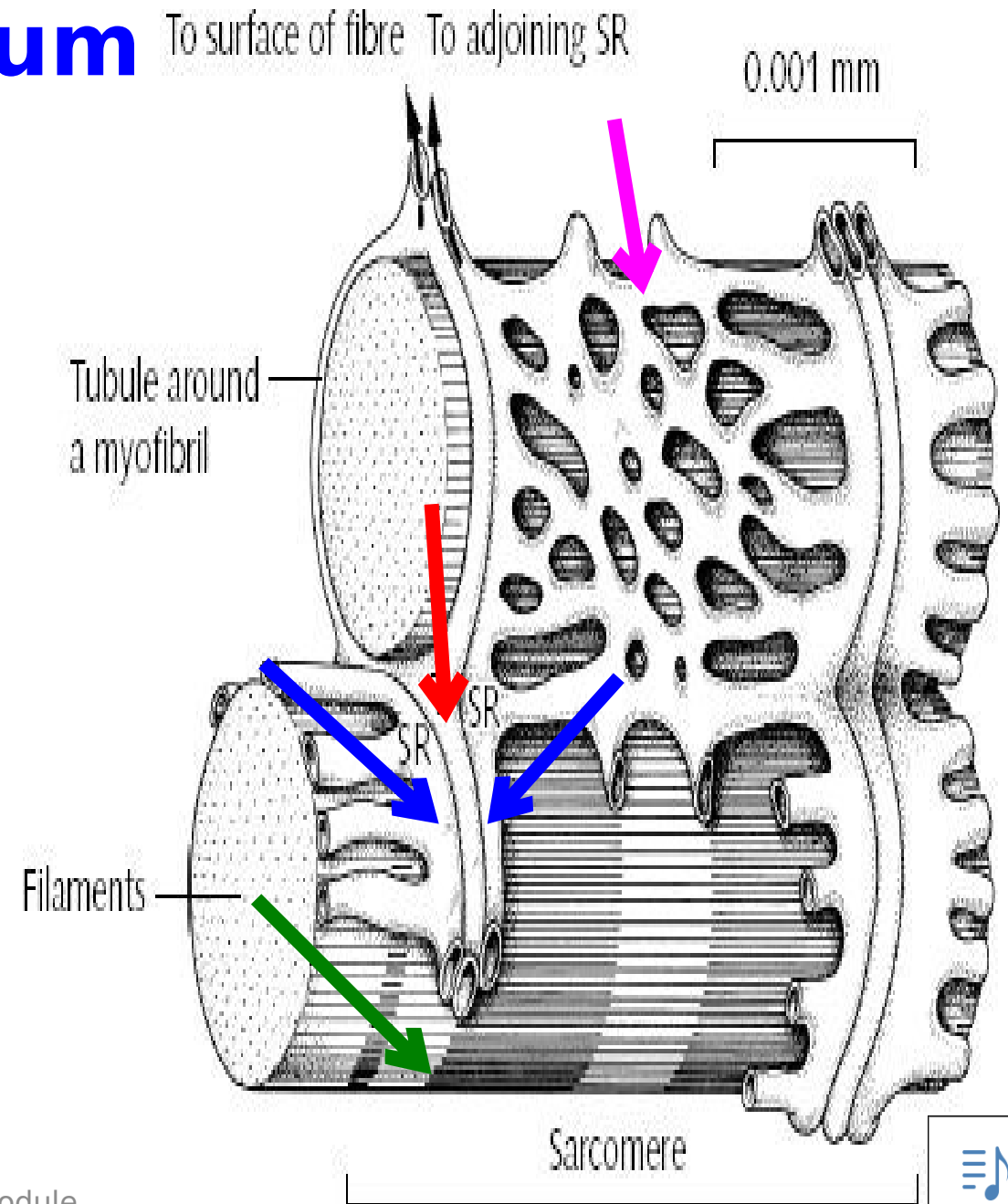
-It conducts the impulse from outer to deeper parts of sk.m.



<http://www.sivabio.50webs.com/mus012.jpg>

3) Sarcoplasmic Reticulum

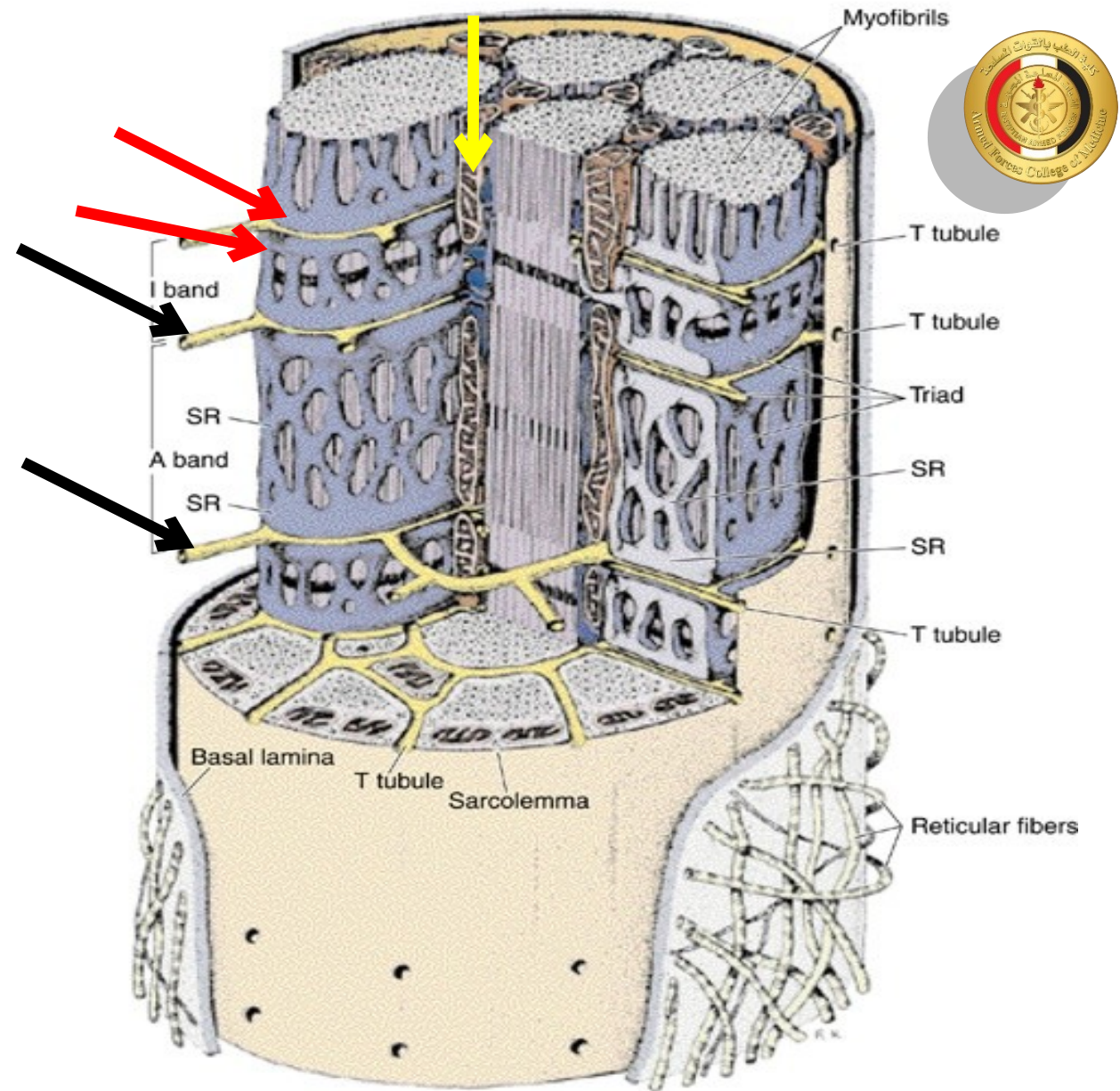
- It is sER
- It forms transverse wide cisternae on each side of T-tubules
- **2 terminal cisternae of sER + T-tubules (Triad at A-I junctions).**
- **Branching network of SR (sarcotubules).**
- **Function:-** regulation of muscle contraction by releasing or sequestering **Ca** (it regulates Ca



Triads

- The invaginations of the **T tubules** occur in the transition **between the A and I bands twice** in every sarcomere.
- They associate with **terminal cisternae** of the **sarcoplasmic reticulum (SR)**, forming **triads**.

Note: Abundant **mitochondria** lie between the myofibrils.



<https://slideplayer.com/slide/13616844/83/images/28/Terminal+cisterna+and+triad.jpg>



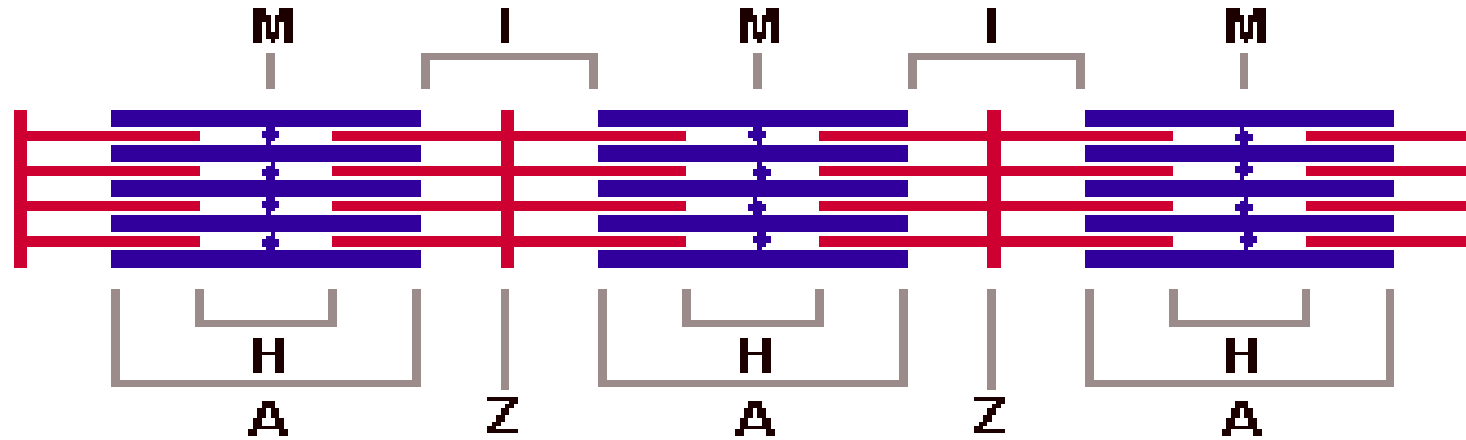


Triads

- There are **2 triads** in each sarcomere
- **Importance of T- tubules & SR:**
 - ✓ nerve impulse → wave of depolarization sweeps along sarcolemma into T- tubules
 - ✓ Depolarization of T- tubules → release of Ca from sER
interaction of actin & myosin → muscle contraction



— myosin — actin



Bands and lines in the contractile apparatus of skeletal muscle

https://media.giphy.com/media/1WSeXiDwhQExO/giphy-facebook_s.jpg

During contraction of the muscle, myofibrils show:

- **Sliding of actin filaments over the myosin** → filaments so thin actin filaments slide towards the middle of the sarcomere **pulling on the 2 z lines** to which they are attached and this **pulls all the sarcomeres closer together resulting in** shortening of the sarcomeres and whole myofibrils. (**a muscle contraction**).
- **H zone disappears**
- **I bands are reduced.**



Lecture Quiz

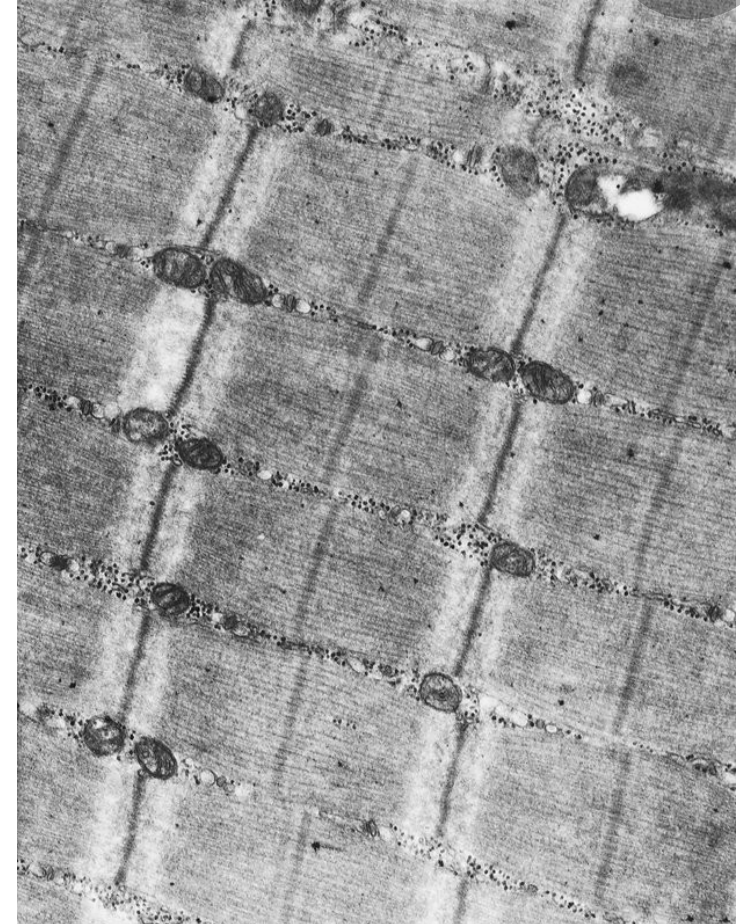


The triad of skeletal muscle fibers is formed of:

- ☒ **A) One T tubule and two terminal cisternae.**
- B) One T tubule and one terminal cisternae.**
- C) Two T tubule and two terminal cisternae.**
- D) Two terminal cisternae.**

Electron microscope

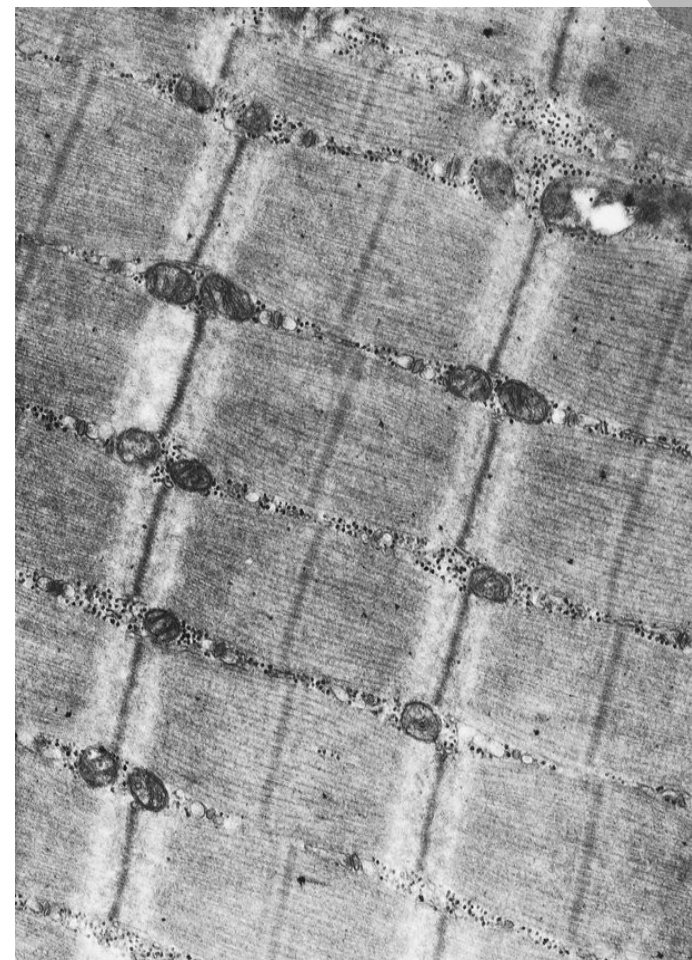
1. Myofibrils & myofilaments
2. Sarcoplasmic Reticulum
3. Sarcolemma & transverse tubules
4. Mitochondria & Ribosomes.
5. Inclusions:-myoglobin & glycogen



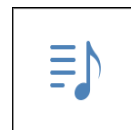
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Electron microscope

1. Myofibrils & myofilaments
2. Sarcoplasmic Reticulum
3. Sarcolemma & transverse tubules
4. Mitochondria & Ribosomes.
5. **Inclusions: myoglobin & glycogen**



<https://media.sciencephoto.com/image/c0397504/800wm>



Inclusions:

- ❑ Glycogen

- ❑ Myoglobin:-

- It is Oxygen binding protein.
- It is functionally & chemically related to HB
- It is red to brown in color.

- According to their conc. in muscle fibers:-
 - 1) Red fibers
 - 2) White fibers
 - 3) Intermediate fibers



Type of skeletal muscle fibers	White muscle fibers (Fast glycolytic fibers)	Intermediate fibers (Fast oxidative glycolytic fibers)	Red muscle fibers (Slow oxidative fibers)
Diameter	Wide	Moderate	Small
Glycogen	High	Moderate	Low
Myoglobin	Low	Moderate	High
Mitochondria	Few	Moderate	Numerous
Contraction	Rapid & short	Moderate	Slow & Long
Fatigue	Easy	Moderate	Not Easy



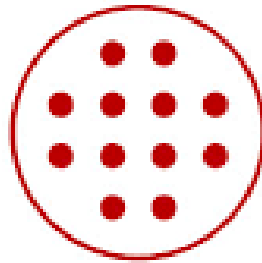
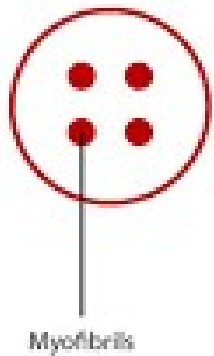


- **Growth of skeletal muscle:**
 - in width** : (hypertrophy)
increase number of myofibrils
- **Regeneration of skeletal muscle:**
 - 1- in children: it has the ability to divide
 - 2- in adult:
 - **small defect:** by satellite cells
 - **large defect:** NOT regenerate (**fibrosis**)



Medical application

Exercise increases muscle size through **Hypertrophy**. This is due to increased synthesis of myofibrils.



In Marathon runners, the slow contraction of the leg muscles for **long periods** would be due to presence of large numbers of **red** muscle fibers type (slow twitch oxidative fibers).



Medical application

In world class sprinters, a high percentage of white muscle fiber types is present (fast-twitch skeletal fibers)



Elite marathoners have way more slow-twitch fibers, and sprinters like **Bolt** have an abundance of fast-twitch ones.



100 meters in 9.58 seconds

<https://qz.com/1043997/usain-bolt-is-the-fastest-human-in-the-world-here-s-the-science-that-shows-how-he-does-it/>



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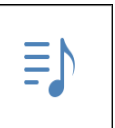
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Medical application

- **Rigor mortis:** stiffening of the skeletal muscles after death. This occurs because calcium leaks into the sarcomere allowing cross-linkage to occur between the filaments and sliding of actin over myosin occurs. Each step in the cycle requires an ATP and ATP is also required to pump calcium ion back into sarcoplasmic reticulum. So, the lack of ATP will not allow the relaxation to occur.



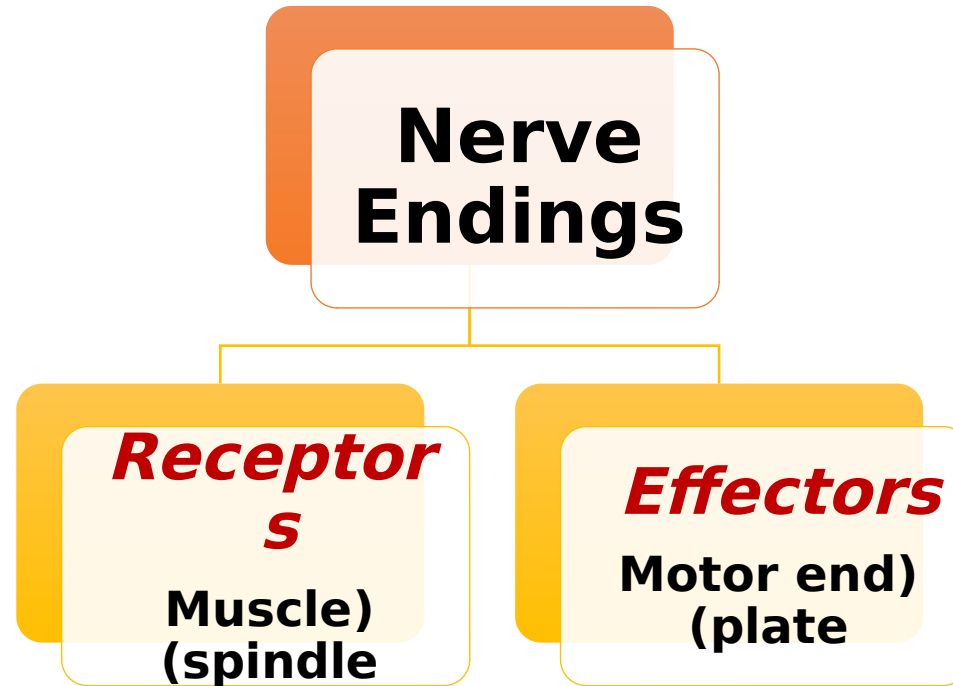
Lecture Quiz



Red muscle fibers are characterized by
:

- A) High glycogen content.**
- B) Few mitochondria.**
- C) Wide diameter.**
- D) High content of myoglobin .**

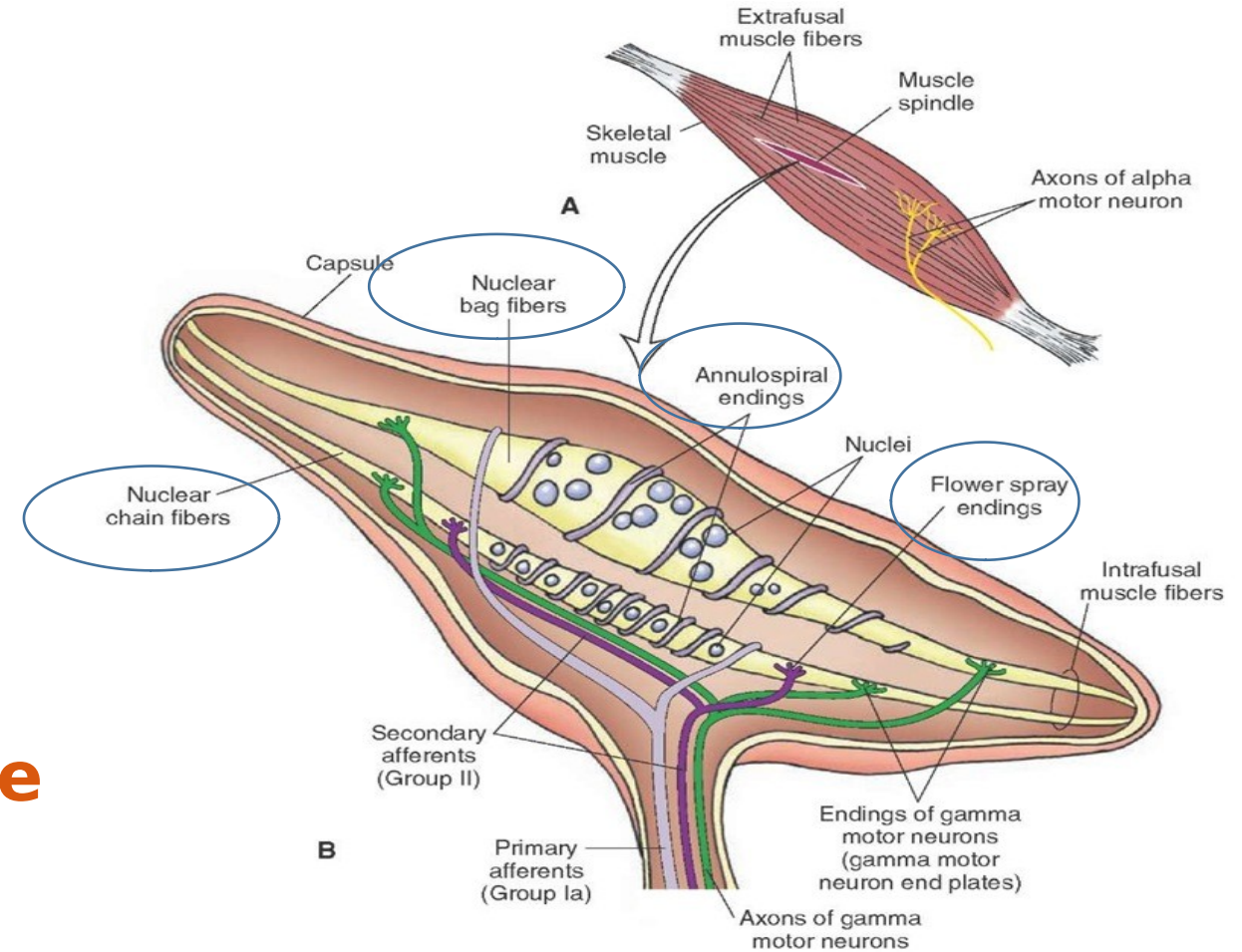
Innervations of Skeletal muscle



Muscle spindle



- **Site:** **Skeletal muscles**
(it is the Stretch Receptors of the muscle)
- **Structure:** **fusiform, capsulated,**
lies parallel to
muscle fibers.
- **Each spindle contains**
2-12 intrafusal muscle
fibers.
- **They have:**
 1. Smaller diameters
 2. Indistinct striations



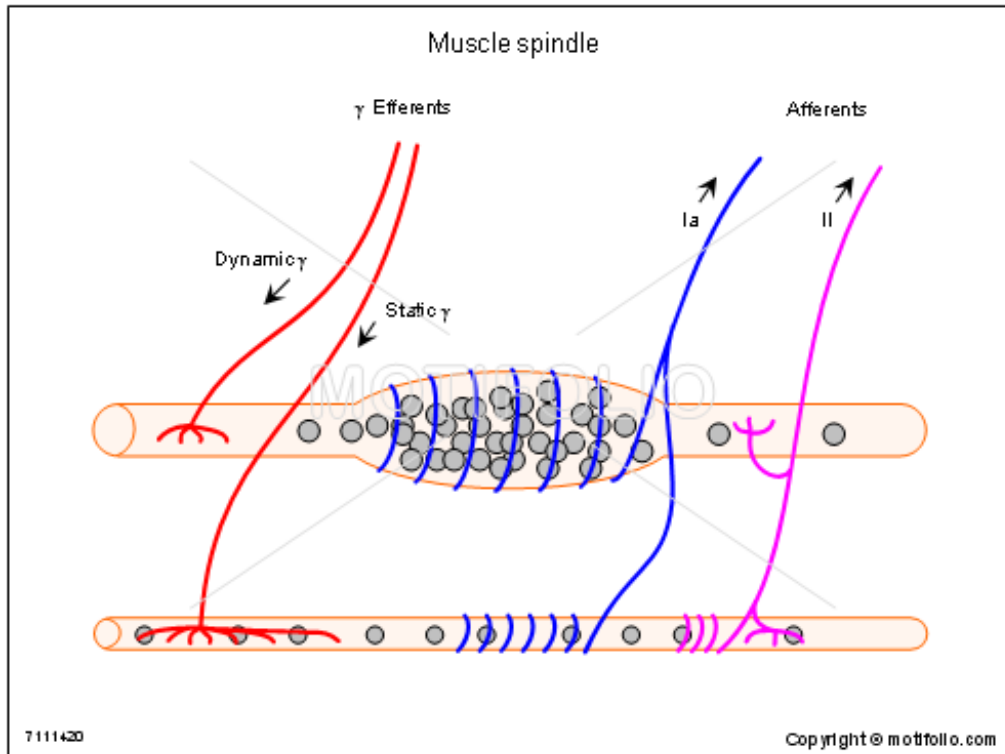
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Muscle Spindle

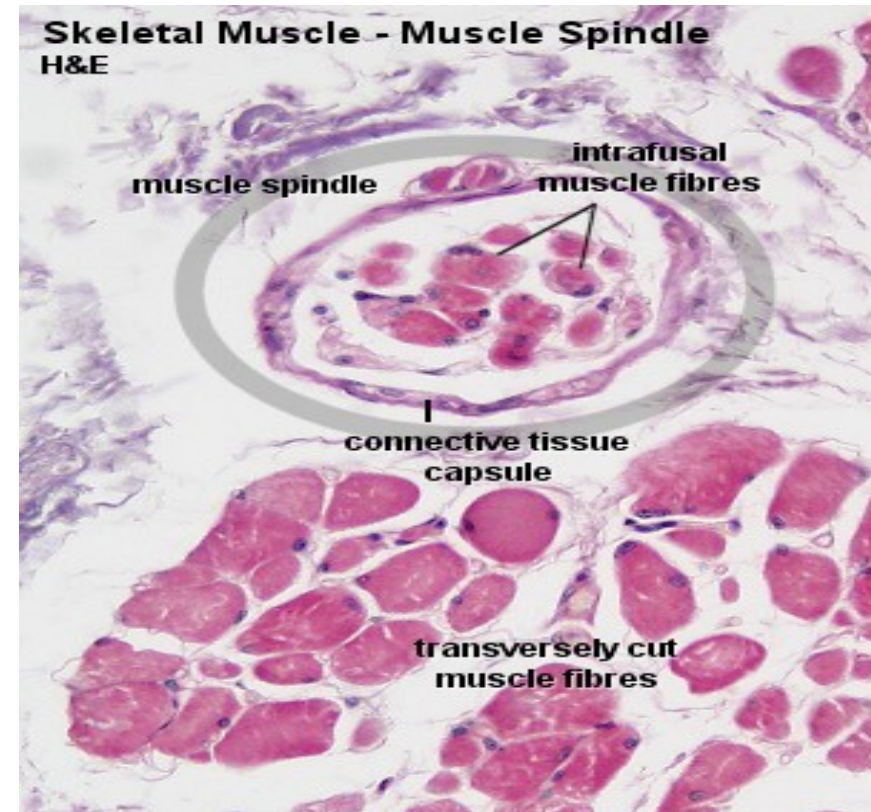


L. S.



<http://site.motifolio.com/images/Muscle-spindle-7111420.png>

T.S.



<http://lecannabiculteur.free.fr/SITES/UNIV%20W.AUSTRALIA/mb140/CorePages/Muscle/Images/MuSpHE20.jpg>



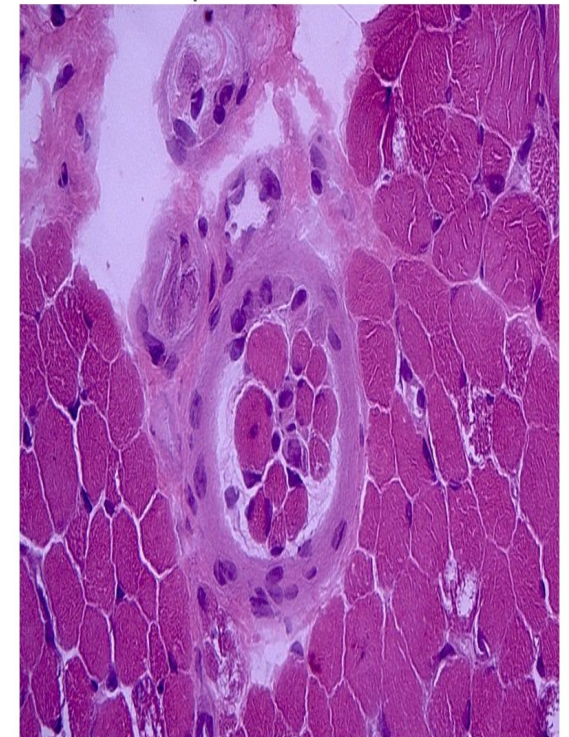
Muscle Spindle



Types of intrafusal fibers:

Nuclear chain	Nuclear bag	
Thin and short	Thick and long	1- Shape
Numerous	Few	2- Number
Arranged in one row	Many central nuclei	3- Nuclei

Muscle spindle – transverse section



doc. MUDr. Josef Zámečník, Ústav patologie a molekulární medicíny 2 LF UK a FN v Motole



Innervations of Muscle Spindle



1- Sensory (Afferent)

A- Annulospiral
(.Primary aff)

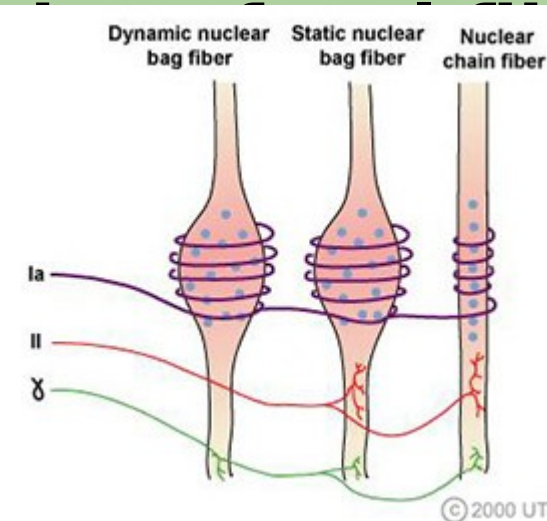
B- Flower spray
(.Secondary aff)

- Terminate around central **non contractile** part *of both fibers.*

- Terminate on each side of the annulospiral ending *of both fibers.*

2- Motor (Efferent)

- Small *gamma* fibers → terminate on the **contractile** parts of the fibers

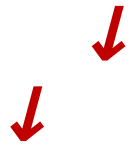


Effectors



- These are termination of peripheral **motor** nerve fibers in the effector organs.
- **They are classified into:**

1- Somatic effectors
Visceral effectors



Supply **skeletal ms.**
Supply **cardiac ms.,**



New Five Year Program

ms. and glands

2-



Motor End Plate

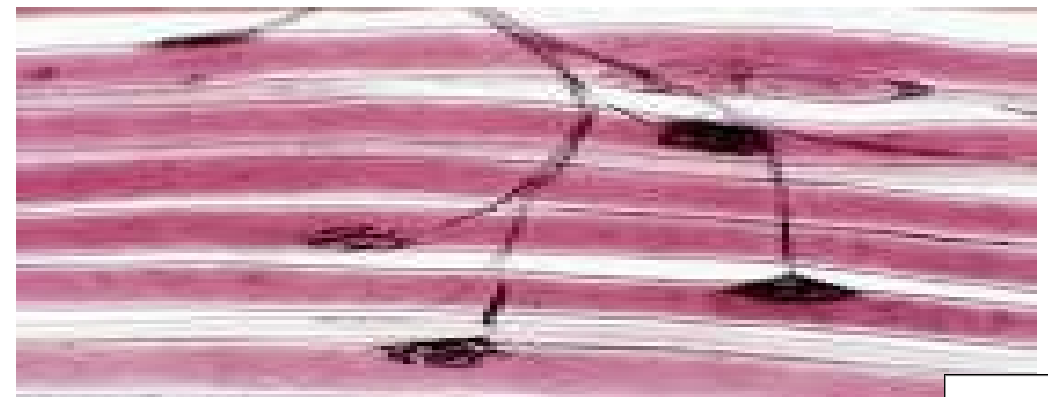


- It is the site of axon termination (from anterior horn cells) on sk.ms.f.
- Each sk.ms.f. is supplied by one motor axon.

Motor unit = AHC + one motor axon + muscle fiber

Can be stained by :

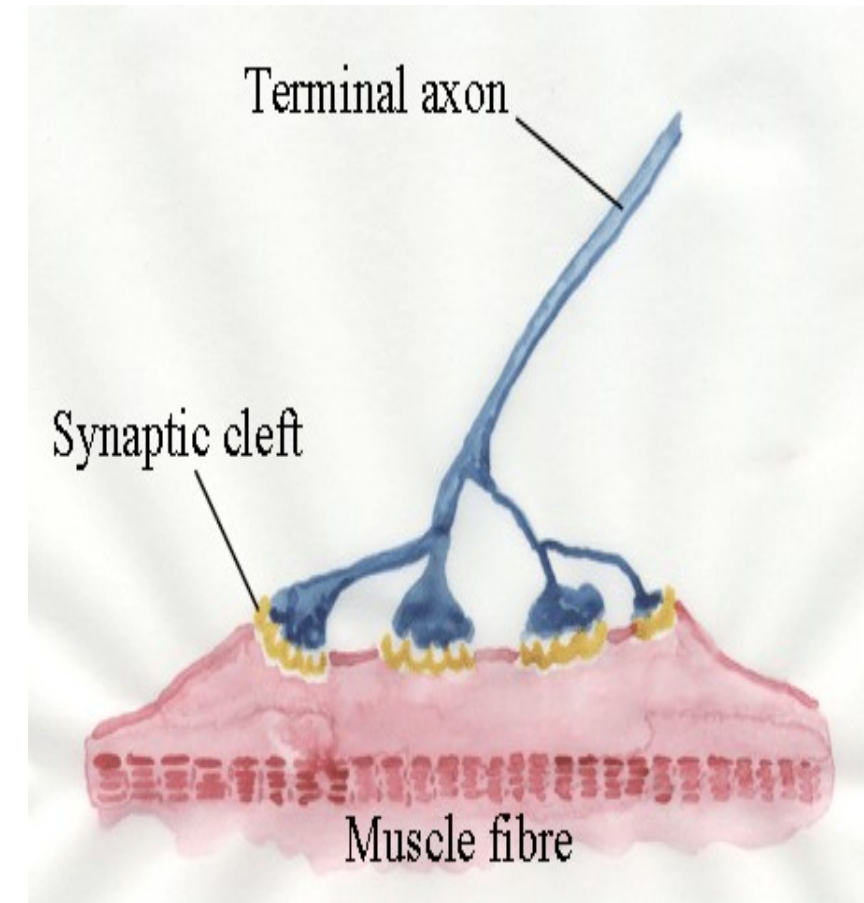
Gold impregnation technique



Structure of Motor End Plate

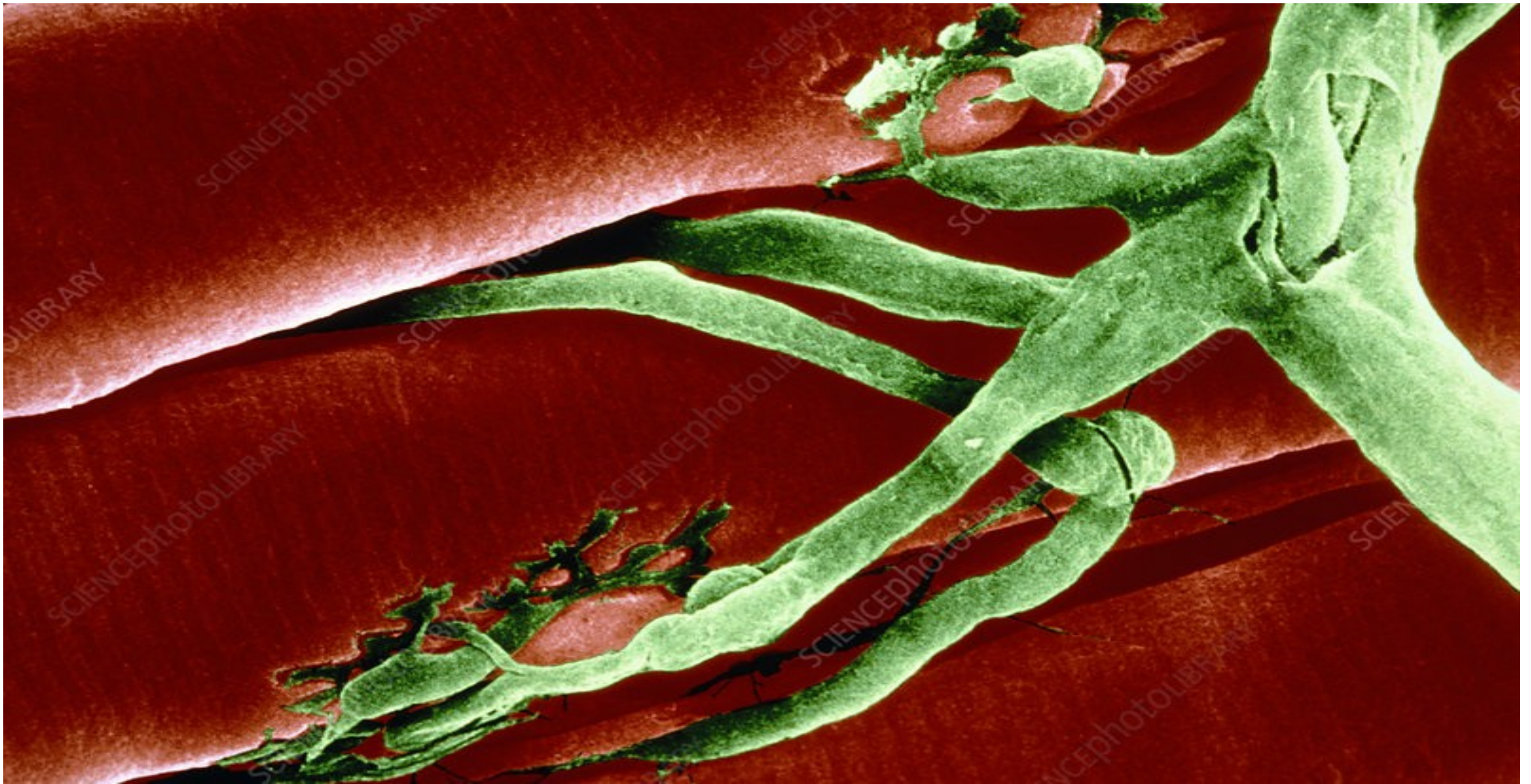


- Site of contact between axon and muscle is called → **motor end plate**.
- **L\|M:**
- Axon loses its myelin → Schwann cells remain to cover axon
→ branches into many terminals
→ each forms depression on sarcolemma → **“trough”**.
- ***Space between axon terminal and sarcolemma is → primary synaptic cleft.***



<https://www.google.com.eg/imgres?imgurl=http%3A%2F%2Fwww.aps.uoguelph.ca%2F~swatland%2FHTML10234%2FLEC6%2FSP37.gif&imgrefurl=http%2F%2Fwww.barzkar2.blogfa.com%2Ftag%2F%25D8%25B5%25D9%2581%25D8%25AD%25D9%2587-%25D8%25B1%25DA%25A9%25D8%25AA%25DB%2587%25A7%25D9%2586%25D8%25AA%25D9%2587%25D8%25A7%25DB%258C%25DB%258C->





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Structure of Motor End Plate



• E\M:

1. Muscle:

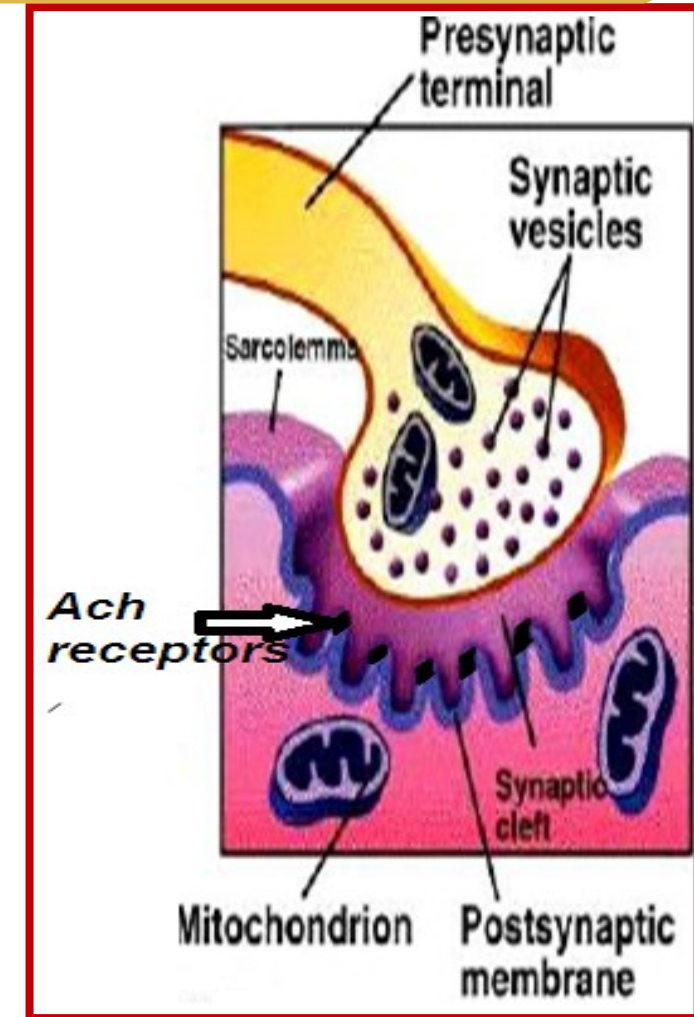
- **Sarcolemma** → many infoldings (2ry synaptic clefts or junctional folds containing Ach receptors)
- **Sarcoplasm** → numerous mitochondria

2. Axon:

- **Axoplasm** → numerous synaptic vesicles and mitochondria.

3. Cleft:

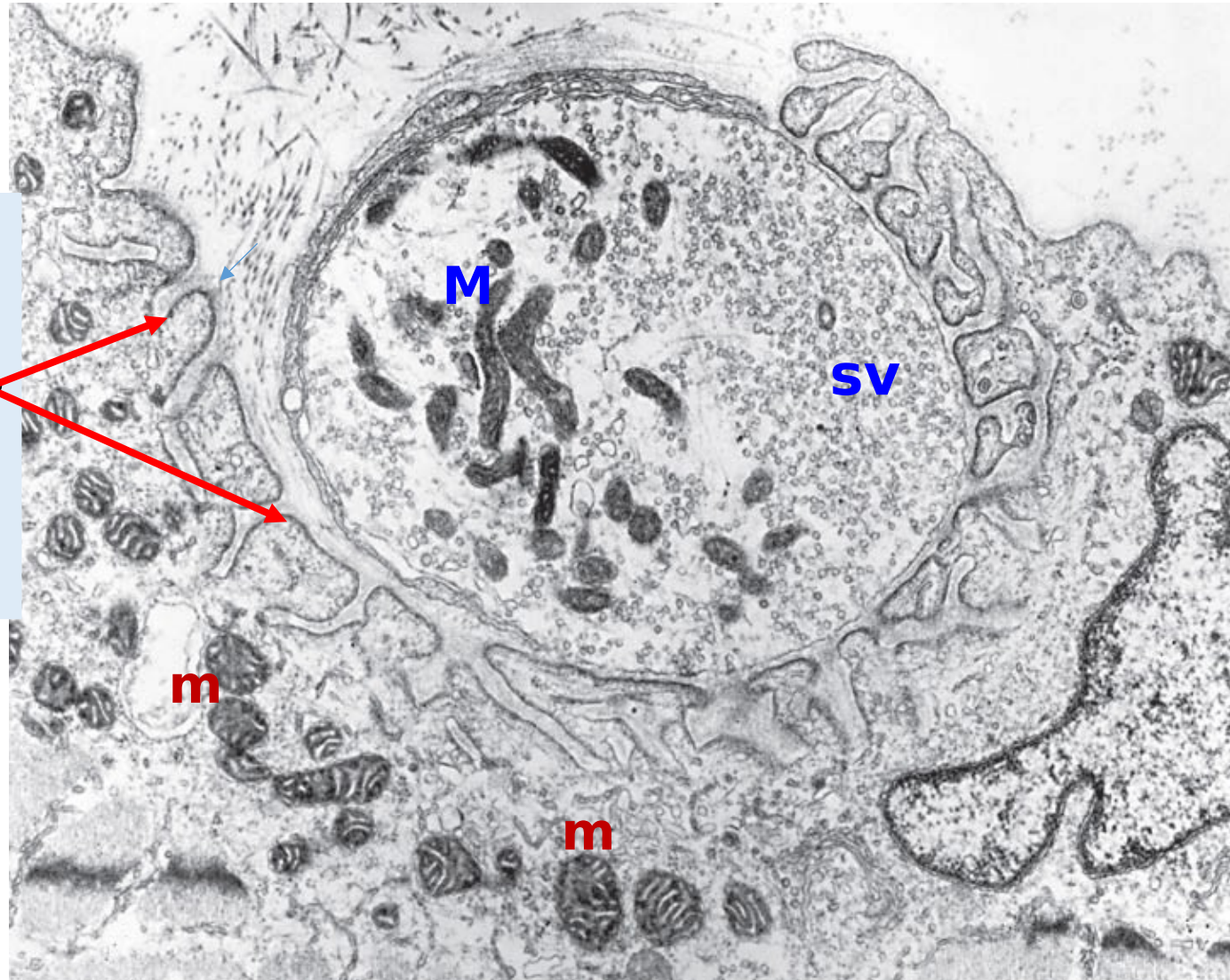
- **Choline-esterase enzyme.**



<https://encrypted-tbn0.gstatic.com/imaq=tbn:ANd9GcQ8ZKXFjYA4W7vIYuJCABiBuwBNyFkjd7dSpQXjZjr>



Structure of Motor End Plate



Muscle

Junctional Folds

**Mitochondria
(m)**

Axon

**Synaptic
vesicles (SV)**

**Mitochondria
(M)**

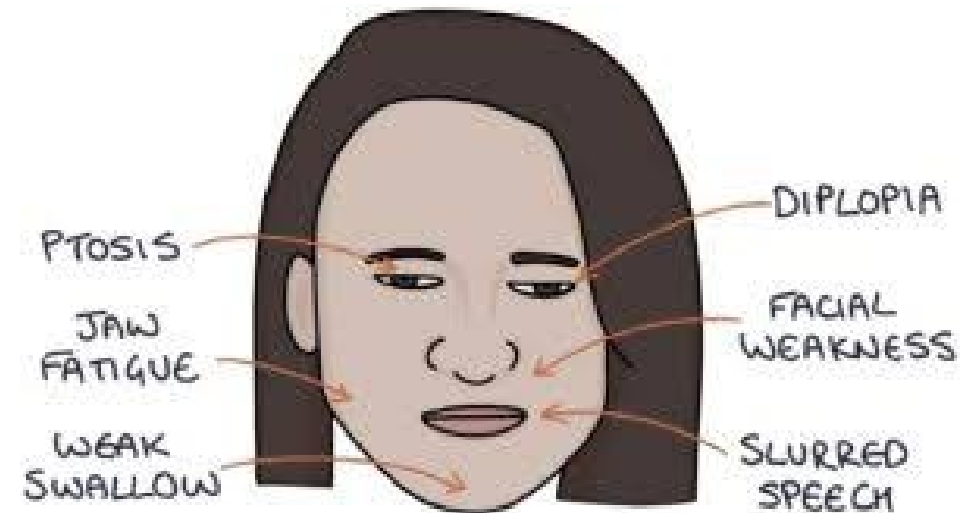


Medical Applications



➤ **Myasthenia gravis** is an autoimmune disease caused by the formation of antibodies to the acetylcholine receptor on the sarcolemma in the junctional folds of the motor endplates.

➤ Affected individuals develop tremendous muscle weakness manifest by fatiguability, inability to lift the arms, failure to maintain an upright posture of the head, and drooping of the eyelids.

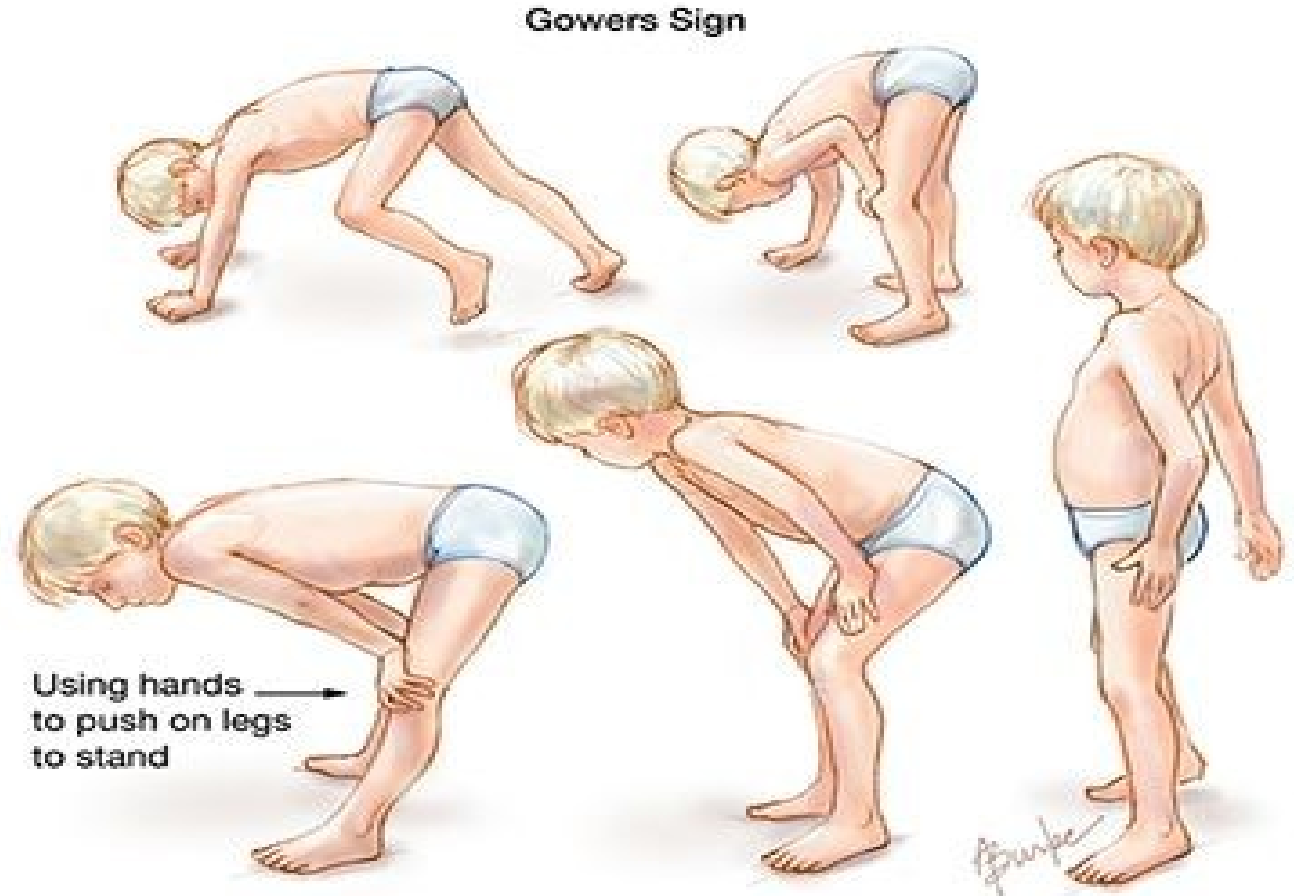


Medical Applications



➤ **Duchenne muscular dystrophy** is the most common inherited muscle disease and characteristically affects male children.

➤ Such individuals become unable to stand unaided in early childhood and develop progressive muscle weakness and typically dying in early adult life.



Medical Applications

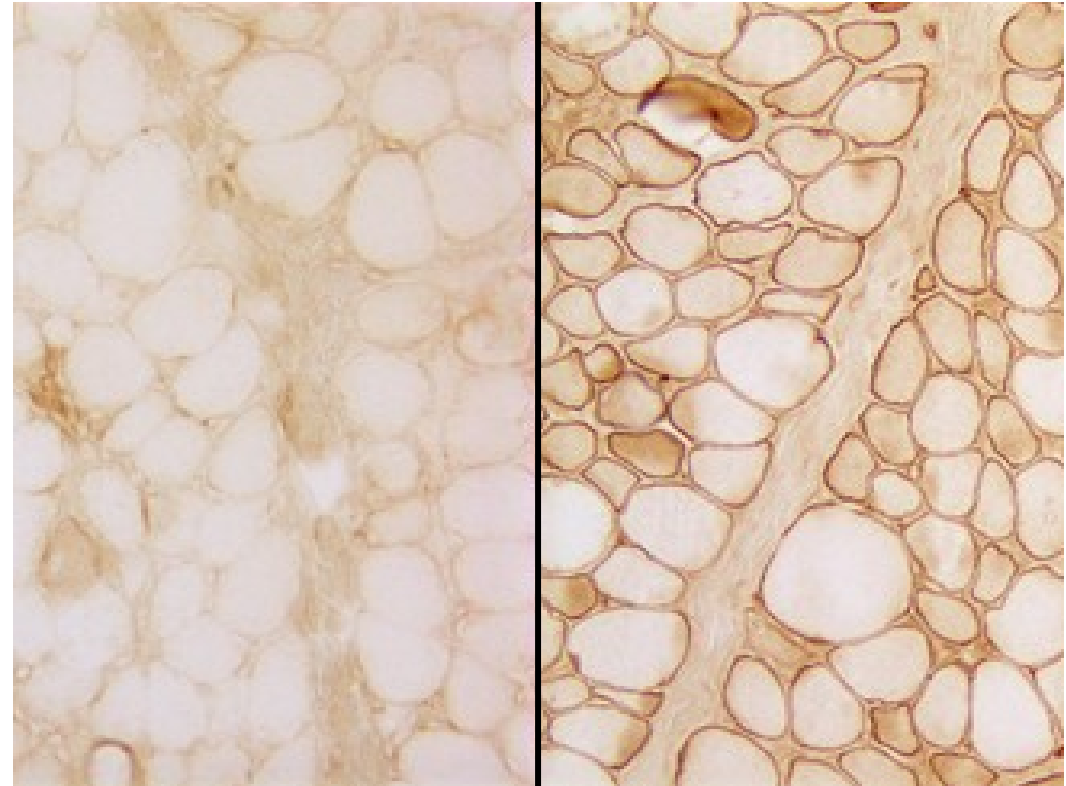


➤ Duchenne muscular dystrophy :

➤ The abnormality in Duchenne muscular dystrophy is due to a defect in the gene coding for a protein termed **(dystrophin)**.

➤ Dystrophin links the actin cytoskeleton of muscle to the external lamina; its absence leads to abnormal muscle fiber fragility.

➤ Dystrophin acts to protect the **muscles** at each contraction, and a lack of dystrophin results in an accumulation of damage and



neuropatholog

v



Lecture Quiz



The Space between axon terminal and sarcoplasm is the:

- A) Synaptic plate.
- B) Synaptic vesicle.
- ☒ C) Synaptic cleft.
- D) Synaptic lacunae

The triad of skeletal muscle fibers is formed



- ☒ A) One T tubule and two terminal cisternae.
- B) One T tubule and one terminal cisternae.
- C) Two T tubule and two terminal cisternae.
- D) Two terminal cisternae.



The Space between axon terminal and sarcolemma is the:



- A) Synaptic plate.
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The efferent motor axons that supply the muscle spindle are:



- A) Alpha fibers.
- B) Beta fibers.
- ☒ C) Gamma fibers.
- D) Delta fibers.



Key Points



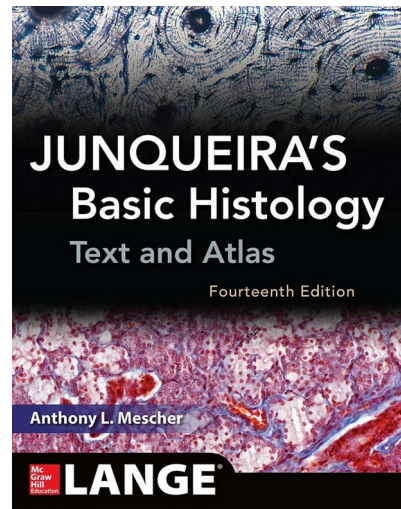
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SUGGESTED TEXTBOOKS

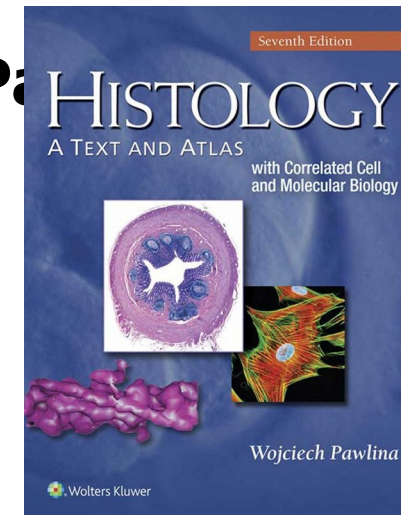


1. Junqueira's Basic Histology: Text and Atlas, Fourteenth Edition by Anthony Mescher (2016)

2. Histology a text and atlas with correlated cell and



biology by W. Pawlina (2016)



THANK
YOU

